in the soil; neither does it do so *inside* the cells. On the *outside* of the membrane (extracellular), however, it measures the negative hydrostatic pressure in the xylem ducts as a straightforward null measurement. It does not matter what causes the negative pressure balance in the xylem sap, nor what adsorptive forces may reside in the vessel walls; nor does it matter whether the ducts run plain water or sap solution. In plants, nevertheless, a close approximation to the turgor pressure (intracellular) can be derived from the pressure-volume curve.

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Mass Extinctions at the End of the Cretaceous Period

The environmental factors that influence communities of living organisms are so complex that they are rarely well understood. Consequently, the problems that confront the paleoecologist may seem insuperable. Yet, recurring regularities in the fossil record of past life tempt paleontologists to venture explanations of real events, now millions of years past, in the history of life. Such an explanation is M. N. Bramlette's stimulating new hypothesis (25 June, p. 1696) to account for revolutionary changes in marine life at the close of the Mesozoic era. His conclusions are based on an exceptionally well-documented case history, and once and for all remove any doubt that marine life has undergone catastrophic changes over wide expanses of the oceans. This is a matter that has long been suspected and much debated. Now that the facts seem well established, the problem is to explain them.

I have cited evidence [(*Sci. Amer.* **208**, 76 (Feb. 1963)] that extinctions of the past display a spectrum of patterns ranging from apparently catastrophic revolutions in the faunas of the world to very slow selective and evolutionary replacement. For the former, I have sought general, rather than specific, causes because some of these mass extinctions have involved both terrestrial and marine animals and have recurring rhythms that would seem to eliminate unique causes. Bramlette considers the apparent synchroneity of extinction of land and sea organisms as unproven and possibly a result of circularity in the method of stratigraphic paleontology, in which rocks are dated by fossils and fossils are dated by the rocks that contain them. However, there cannot now be any reasonable doubt that these and comparable changes in world faunas were compressed into time intervals that were very short as measured on the scale of geologic time. It seems to me reasonable to conclude that worldwide vicissitudes among organisms were the result of recurring general ecological disturbances that destroyed the most fragile populations of both land and marine animals. Extinctions on a massive scale clearly were highly selective among animals, affecting some groups while sparing others, but it is one of the unsolved problems of paleontology that plants were not simultaneously and equally affected by crises in the animal kingdom.

Bramlette's interesting hypothesis explains mass extinctions in marine fauna at the close of the Mesozoic era by gradual failure of supply of nutrient salts and sudden collapse of the worldwide ecosystem at a threshold point in a gradual diminution of supply of land-derived sediments carried to the sea by streams. This hypothesis is intriguing and highly promising, but in the present form it seems vulnerable on two counts. In the first place, terrestrial animals did indeed undergo important mass extinctions at approximately the same time as marine animals near or at the close of the Permian, Triassic, and Cretaceous periods. It is incredible that the supply of nutrient salts to the sea would directly affect land animals.

It is also probable that fluctuations of the rate of supply of land-derived nutrients are not nearly as important as variations in oceanic circulation, particularly upwelling, in determining the concentration of nutrients in the euphotic zone. Marine ecologists believe that by far the greatest part of immediately available nutrient salts are contained in the deep basins of the oceans. These salts are continuously recycled by oceanic circulation. Compared with this reservoir, the annual increment from the lands must be infinitesimal. In areas of rapid sedimentation, of course, much nutrient matter is buried in marine sediments before it can be recycled by organisms. Intermittent stagnation of one or more of the ocean basins by whatever means would, of course, produce an immediate deficit in the available budget of marine nutrients. Such stagnation might conceivably have occurred as a result of rapid diastrophic or climatic episodes [see, for example, A. G. Fischer, in *Problems in Palaeoclimatology*, A. E. M. Nairn, Ed., Interscience (Wiley), New York, 1965], but the climatic oscillations of the Pleistocene did not bring about noteworthy mass extinctions of major terrestrial or marine communities (mass extinctions of large herbivorous mammals occurred mainly after the last major retreat of the Pleistocene glaciers). Perhaps the environmental changes of the Pleistocene were too slow, not sufficiently protracted, and of too limited range.

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Severe-Weather Forecasting

John Walsh's article "Tornadoes: Weather Bureau office in Kansas City is nerve center for severe weather warning network" (News and Comment, 4 June, p. 1306) presents an excellent, concise summary of the U.S. Weather Bureau's activities in forecasting severe local storms. The article is concerned with the contributions of a specific agency in this area and does not purport to include a survey of the work of other units. However, mention is made in general terms of improvement in knowledge of thunderstorms during World War II and the demand for better severe-storm forecasting, which is attributed to the rise in commercial air traffic.

Therefore I believe that a few comments concerning the implementation of techniques and units for severe-weather forecasts are appropriate. Before World War II meteorologists generally agreed that forecasts of time and place of tornado occurrences were beyond the state of the art. During 1948, Ernest J. Fawbush and Robert C. Miller of the Air Weather Service detachment at Tinker Air Force Base, Oklahoma, developed available techniques into a reliable system for forecasting severe local storms. In 1949 the Air Weather Service invited U.S. Weather Bureau regional directors at Oklahoma City, Kansas City, and Fort Worth to visit Tinker AFB. As a result of their meeting with Fawbush and Miller, arrangements were made for the direct transmission of the Air Weather Service's severe-weather forecasts affecting Arkansas, Kansas, Missouri, Oklahoma, and northern Texas to the U.S. Weather Bureau offices at Oklahoma City and Kansas City. These forecasts were monitored by the U.S. Weather Bureau for use in warning the civilian population when the situation warranted such action.

In 1950 the Gulf Coast states were added to the area of responsibility, and in 1951 the Air Force Severe Weather Warning Center (SWWC) was established with responsibility to provide forecast coverage for the entire continental United States between the Appalachians and the Rockies. The awareness by certain civilians and the newspapers of the existence of these forecasts prompted a demand for similar forecast services to the general public. Accordingly, in March 1952 the U.S. Weather Bureau established a specialized forecast unit, known as the Severe Local Storms Unit, in Washington, D.C. This unit moved to Kansas City in 1954. The U.S. Weather Bureau Severe Local Storms Unit and the Air Force Severe Weather Warning Center were collocated in 1956 at Kansas City.

As a result of their pioneering investigations and development of techniques for forecasting tornadoes and other destructive local storms, Fawbush and Miller were presented the Meisinger Award of the American Meteorological Society in 1956.

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"Wasted" Water

I am impressed with the sober thoughts of D. B. Luten (Letters, 9 July, p. 133) on some of the burgeoning plans to conserve our natural resources. At all levels of government and among the public in the United States there appears to be a hard-core belief in BIG projects to provide water in greater quantities to specific places for specific purposes. The NAWAPA proposal referred to by Luten is one such project, but there are others of equal importance because of their implications. It seems that everyone is